Department of Toxic Substances Control

Edwin F. Lowry, Director
8800 Cal Center Drive
Sacramento, California 95826-3200

Winston H. Hickox
Agency Secretary
California Environmental
Protection Agency

Gray Davis
Governor

October 23, 2003

Mr. John Hill
Closure Business Line Team Leader
Department of the Navy
Southwest Division
Naval Facilities Engineering Command
1220 Pacific Highway
San Diego, California 92132-5190

CONCURRENCE WITH FINAL FINDING OF SUITABILITY TO TRANSFER (FOST) FOR PHASE IVC PROPERTY, DEPARTMENT OF DEFENSE HOUSING FACILITY NOVATO (PORTIONS OF PARCELS 28, 29 AND 30), LOCATED ON THE FORMER HAMILTON ARMY AIRFIELD, DATED AUGUST 1, 2003, AND ITS AMENDMENT DATED SEPTEMBER 15, 2003

Dear Mr. Hill:

The Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB), (collectively, the State), have reviewed the above referenced documents. The State hereby concurs with the FOST, as amended on September 15, 2003.

The FOST was amended in September to document the revision in the risk assessment for the occupational receptor and the excavation worker. DTSC determined that the Property with the use restrictions remain protective of human health. (Please see DTSC's memos enclosed).

The property overlies groundwater contaminated with methyl tertiary butyl ether (MTBE) and benzene, toluene, ethylbenzene and total xylenes (BTEX). Remediation of groundwater is currently underway pursuant to the Final Corrective Action Plan (CAP) for groundwater for Former Underground Storage Tank Site 957/970 dated March 1, 2002. Soil contaminated primarily with hydrocarbons remains under the footers of Building 970 (see Final Summary Report for Hydraulic Lift Report and Oil/Water Separator Removal from Building 970, dated May 2003).

The State previously gave verbal concurrence for the FOST in August 2003 based on the Navy's commitment to negotiate a Land Use Covenant (LUC) with the State to implement land use restrictions (a component of the remedy) for soil and groundwater. The State signed and forwarded the final LUC to the Navy on September 18, 2002 for its signature and recording with the deed.

DTSC also previously determined Parcels 28, 29 and 30 require No Further Action with regard to the release of Hazardous Substances, except for petroleum releases from the gas stations (See previously issued DTSC letters dated December 12, 1997 and June 30, 1997). The FOST finds the property suitable for its intended use, subject to compliance with the covenants, conditions and restrictions.

To complete the State's Site Mitigation Process, the Phase IVC property will be included in the basewide Remedial Action Plan and subsequent DTSC Certification.

The State reserves the right to address any appropriate environmental or human health related issues should additional information concerning the environmental condition of subject property become available in the future.

Furthermore, please note that should this property be considered for the proposed acquisition and/or construction of school properties utilizing state funding, a separate environmental review process in compliance with California Education Code 12710 et.seq, will need to be conducted and approved by DTSC.

If you have any questions, please feel free to contact Ms. Theresa McGarry, Project Manager, at (916) 255-3664.

Sincerely,

Daniel T. Ward, P.E.
Chief
Base Closure Unit
Office of Military Facilities

Enclosures

cc: See next page.

cc: Mr. Jim Davies
Davies Associates
5 Amalfi Place
San Rafael, California 94901-4308

Mr. Ken Bell
RBF Associates
14725 Alton Parkway
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Mr. Thomas L. Macchiarella
BRAC Environmental Coordinator
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1220 Pacific Highway
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Mr. John Chesnutt
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, California 94105

Mr. Jim Ponton
Regional Water Quality Control Board
San Francisco Bay Division
1515 Clay Street #1400
Oakland, California 94612

Ms. Theresa McGarry
Project Manager
Office of Military Facilities
Department of Toxic Substances Control
8800 Cal Center Drive
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Department of Toxic Substances Control

Winston H. Hickox
Agency Secretary
California Environmental
Protection Agency

Edwin F. Lowry, Director
1001 I Street, 25th Floor
P.O. Box 806
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Gray Davis
Governor

MEMORANDUM

TO: Theresa McGarry
Department of Toxic Substances Control
Office of Military Facilities
Northern California Operations Branch
8800 Cal Center Drive
Sacramento, California 95826

From: Patty Wong-Yim, Ph.D.
Staff Toxicologist
and
Michael J. Wade, Ph.D., DABT
Senior Toxicologist
Human and Ecological Risk Division (HERD)

DATE: September 15, 2003

SUBJECT: Revisions 2 and 3 of the Human Health Risk Assessment for Department of Defense Housing Facility, Novato, Marin County California. Documents dated September 4, 2003 and September 11, 2003

PCA: 18040 Site Code: 200529-18

BACKGROUND

In response to your verbal request on September 10, 2003, HERD has evaluated Revisions 2 and 3 of the Human Health Risk Assessment for the Department of Defense Housing Facility, Sale Area, Novato, Marin County California. We have reviewed the revised human health risks from exposure to contaminants in the Sale Area for all potential human receptors. This parcel is slated for transfer to the City of Novato. The Site borders the former Hamilton Army Airfield Property in Marin County adjacent to the City of Novato. On September 4, 2003, the Navy's contractor (Battelle)

prepared a revised risk assessment for soil and ground water contamination at the Department of Defense Housing Facility originating from an underground fuel tank associated with a gas station (now demolished) which previously existed on the Navy property.

Previous Activity on this Issue

On August 5, 2003, HERD issued a memorandum to provide information on cancer risks from exposure to ethylbenzene based on updated toxicity criteria for ethylbenzene from the 2002 USEPA Region IX Preliminary Remediation Goals (USEPA, 2002). In the memorandum, we further pointed out that inaccuracies were present in outdoor air risk evaluations for both hypothetical future residents and the industrial workers at the Sale Area.

HERD EVALUATION

HERD has reviewed the revised human health risks from exposure to contaminants in groundwater and soil at the Sale Area. Based on the revised data from outdoor air modeling and risk calculations, we concur with the Navy on cumulative cancer risks and hazard indices (HI's) for the hypothetical future residents and the industrial workers at the Sale Area presented in the Revision 2 document, and those for the construction workers at the Sale Area presented in the Revision 3 document.

However, HERD believes that the potential cancer risks for construction workers from exposure to ethylbenzene in soil and groundwater are incorrect (Section 4, Revision 2). According to the human health risk assessment report, cancer risks for construction workers were derived based on an exposure assumption of 30 days excavation activity at the Sale Area. Thus, an exposure frequency (EF) of 30 day/yr was listed in Table 4-1 and used in risk calculations. Nevertheless, an exposure duration (ED) of 0.083 yr (1-12th of the year) was also listed in Table 4-1 and used in the risk calculations. Consequently, the total exposure time for construction workers becomes 2.5 days (30 day/yr X 1/12 yr) for performing excavation at the Sale Area, instead of 30 days. As a result, the cumulative construction worker risk was underestimated by a factor of 12. HERD has re-evaluated the cancer risks for construction workers, including cancer risks from exposure to ethylbenzene in soil and groundwater, and includes the recommended risks in the following tables.

Table 1. Cancer Risks for Construction Workers from Exposure to Contaminants in Soil and Groundwater at the Sale Area

Contaminants	Ambient Air Risk	Soil Risk
1,2,4-Trimethylbenzene	0.00E+00	0.00E+00
1,3,5-Trimethylbenzene	0.00E+00	0.00E+00
Benzene[(a)]	2.05E-05	2.28E-09
Cumene	0.00E+00	0.00E+00
Ethylbenzene	1.45E-06	2.80E-10
MTBE	1.81E-07	1.17E-10
Naphthalene	0.00E+00	0.00E+00
n-Propylbenzene	0.00E+00	0.00E+00
Toluene	0.00E+00	0.00E+00
Xylenes	0.00E+00	0.00E+00
Total	2.21E-05	2.68E-09

[(a)] Cancer risks for benzene were determined based on California cancer slope factors for benzene from OEHHA.

Table 2. Cumulative Cancer Risk for Construction Workers.

	Cumulative Risk[(a)]	Cumulative Risk without Ethylbenzene[(a)]
New Risk	2.22E-05	2.07E-05
Risk from Revision 2	1.85E-06	1.73E-06

[(a)] Cancer risks for benzene were determined based on California cancer slope factors for benzene from OEHHA.

DISCUSSION AND CONCLUSION

In responses to HERD's memorandum, dated August 5, 2003, the Navy issued a Revision 2 document for the Final Revised Risk Assessment for Former UST Site 957/970 Department of Defense Housing Facility Novato, California. Overall, HERD concurs with the revised cumulative cancer risks and HI's for the hypothetical residents and the industrial workers at the Sale Area. However, we believe the cancer risks for

construction workers were underestimated. HERD's recommended revisions for construction workers are listed above in Tables 1 and 2.

During the preparation of this memorandum, the Navy issued a further revision with revised cumulative cancer risks for construction workers. These revised risks for construction workers are similar to those calculated by HERD and include ethylbenzene as a carcinogen. This comparison is based on the Cal/EPA cancer slope factor for benzene for both the DTSC and Navy estimates. All risks remain within the risk management range (i.e. 1E-6 to 1E-4). More importantly, a construction worker HI of 1,130 is determined at the Sale Area. Based on this, protective measures probably including some form of respiratory protection and protective clothing would be required for workers excavating and working in areas covered by the deed restriction (three or five feet below ground surface). These protective measures would greatly reduce the potential cancer risk to the workers. The recommended revision in cancer risk for construction workers should not have a significant influence on future land use decisions and deed restrictions proposed to be imposed at the Sale Area.

cc: Michael Schum, Ph.D.
Staff Toxicologist, HERD

REFERENCES

US EPA Region XI Preliminary Remediation Goals, (2002). Memorandum from Stanford Smucker, Ph.D., Regional Toxicologist.
(http://www.epa.gov/region09/waste/sfund/prg/index.htm).

Department of Toxic Substances Control

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MEMORANDUM

TO: Theresa McGarry
Department of Toxic Substances Control
Office of Military Facilities
Northern California Operations Branch
8800 Cal Center Drive
Sacramento, California 95826

From: Patty Wong-Yim, Ph.D.
Staff Toxicologist
and
Michael J. Wade, Ph.D., DABT
Senior Toxicologist
Human and Ecological Risk Division (HERD)

DATE: August 5, 2003

SUBJECT: Ethylbenzene: Human Health Risk Assessment for Department of Defense Housing Facility, Novato, Marin County California. Document dated June 8, 2001.

PCA: 18040 Site Code: 200529-18

BACKGROUND

In response to your verbal request on July 25, 2003, HERD has evaluated the potential risks related to vapor emission and soil contact with ethylbenzene in soil, soil gas and ground water in the Sale Area at Department of Defense (DOD) housing facility. This parcel is slated for transfer to the City of Novato. The Site borders the former Hamilton Army Airfield Property in Marin County adjacent to the City of Novato. In June 2001, the Navy's contractor (Battelle) prepared a risk assessment for soil and ground water contamination at the Department of Defense Housing Facility originating from an

underground fuel tank associated with a gas station (now demolished) which previously existed on the Navy property. The contamination had been previously treated by source removal (excavation). A soil vapor extraction system was operated from 1998 to 1999. Some areas of the site have been treated by biosparging since September 2002, but this only extends to part of the Sale Area. Soil gas is monitored monthly and groundwater is generally monitored quarterly for contaminant concentrations. The Navy's risk assessment identified benzene and methyl-tert-butyl ether (MTBE) as primary drivers of carcinogenic risk at the site. At the time the risk assessment was performed by the Navy, ethylbenzene was not classified by USEPA as a carcinogen. However, recently, based on results from a new rodent carcinogenicity bioassay performed by the National Toxicology Program (NTP), USEPA's National Center for Environmental Assessment (NCEA) has determined that ethyl-benzene is carcinogenic and calculated inhalation and oral cancer slope factors of 3.85E-3 $(mg/kg\text{-}day)^{-1}$ for ethylbenzene (USEPA, 2002a). These values are cited in the most recent compendium of Preliminary Remedial Goals (PRGs) issued by USEPA Region 9 (USEPA, 2002b).

Previous Activity on this Issue

In a memo from Michael Schum dated July 6, 2001, HERD reviewed the Navy's June 2001 risk assessment for contamination originating from gasoline leaking from a former underground storage tank. HERD generally accepted the Navy's conclusions from that risk assessment. In February of 2003, HERD provided comments to OMF on the Internal Draft Phase IVC FOST for Exchange Parcel 1.

HERD EVALUATION

Toxicity Criteria and Exposure Parameters

HERD estimated ethylbenzene related risks for the residential and industrial scenarios according to parameters utilized in the Navy's risk assessment (Battelle, 2001). HERD also recalculated the risks from the other VOCs present as risk drivers (benzene and MTBE). The excavation scenario estimated in the Navy's document was not included in our calculations because the Navy's results indicated that the hazard associated with excavation was unacceptable without special land use controls. Therefore, given that protective measures would be needed to limit exposure to benzene and MTBE in the case of excavation into contaminated areas, we did not evaluate this exposure scenario for ethylbenzene since protective measures would mitigate that risk also.

Exposure Pathways

HERD evaluated potential human health risks from direct contact to ethylbenzene in

impacted soil at the Sale Area, inhalation exposure to indoor air due to vapor intrusion, and inhalation exposure to outdoor air due to ethylbenzene released from soil and groundwater. HERD evaluated the risks using the current inhalation and oral cancer slope factors (CSFi and CSFo) adopted by the USEPA Region 9 (USEPA, 2002b). Detailed chemical risks calculated for each pathway are summarized in Attachment 1.

Indoor Air Pathway: Indoor air risks for the residential and industrial worker scenarios are estimated by the DTSC spreadsheet version of the USEPA Johnson and Ettinger vapor intrusion model (USEPA, 2000), using the current CSFi for ethylbenzene (USEPA, 2002b). Soil gas concentration of ethylbenzene at soil gas location SG-16 collected in Fall 2000 (42.5 ppbv, Appendix H, Battelle, 2001) is used as the input concentration in the indoor air model. Printouts of the indoor air model results are attached to this memorandum for reference (Attachment 2).

Outdoor Air Pathway: Predicted outdoor air concentrations of ethylbenzene at the Sale Area (Table 3-7 and Table 3-11, Battelle, 2001) are used as exposure point concentrations (EPCs) in the outdoor air risks calculation. A unit risk factor (URF) of 1.1E-6 $(\mu g/m^3)^{-1}$ for ethylbenzene is derived from the current CSFi (USEPA, 2002b). Equation 3-1 from the Navy's risk assessment (page 3-1, Battelle, 2001) is used in deriving outdoor air risks for ethylbenzene.

Soil Pathway: Risks from direct contact with impacted soil at the Sale Area are determined using the 95% UCL concentration of ethylbenzene in soil (Table 3-11, Battelle, 2001) as an EPC. Risk equation 3-12 in the Navy's risk assessment (Page 3-12, Battelle, 2001), and the current CSFo for ethylbenzene (USEPA, 2002b) are also used in this calculation.

Table 1. Exposure Point Concentrations in Sale Area and Toxicity Criteria

Contaminant	95% UCL[a] concentration in soil (mg/kg)	Maximum Concentration in groundwater (mg/L)	Concentration in soil gas at SG-16 (ppbv)	Inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$
Ethyl-benzene	3.906	0.9	42.5	3.85E-3	3.85E-3
Benzene	2.248	1.6	759.3	1E-1[b]	5.5E-2
MTBE	3.576	35	2866	9.0E-4	1.8E-3

[a] 95 percent upper confident limit of the mean (95% UCL)
[b] The Cal EPA CSFi for benzene is used

Table 2. Cancer Risks of VOCs at the Sale Area

Contaminant	Residential Risk	Industrial Risk
Ethylbenzene	8E-7	3E-7
Benzene	2.7E-5	1.6E-5
MTBE	7E-7	4E-7
All contaminants (total risk)	2.8E-5	1.6E-5

DISCUSSION AND CONCLUSION

After completion of the risk assessment for the fuel related contamination at the DOD Facility in Novato, Region 9 USEPA identified ethylbenzene as a carcinogen and listed a cancer slope factor for it. HERD calculated the carcinogenic risk from ethylbenzene present in the Sale Area at the DOD Housing Facility that is slated for transfer to the City of Novato. HERD also recalculated the risks from the other VOCs present as risk drivers (benzene and MTBE). Our calculations estimated that the total industrial risk from all VOCs in the Sale Area is about 2.8E-5 for a residential exposure scenario and 1.6E-5 for an industrial exposure scenario compared to the values of 1.5E-5 and 8.3E-6 respectively, identified in the 2001 Battelle document. The risks estimated by HERD exceed the point of departure of 1×10^{-6} listed in the National Contingency Plan (NCP), but are within the 1×10^{-6} to 1×10^{-4} risk management range cited in the NCP. HERD understands that the Sale Area will be developed for commercial/ industrial use. Several health protective assumptions were utilized in both the HERD and Battelle calculations which tend to overestimate risk, including use of maximum soil gas and groundwater concentrations and use of a health protective model for estimating concentrations of contaminants in outdoor air. Additionally the models used to estimate indoor and outdoor air concentrations assumed a non-depleting source, whereas in fact the source is finite and active remediation is ongoing in some of the contaminated areas. HERD expects that soil, ground water and soil gas concentrations of site related VOCs will decrease over time with a resultant decrease in site related risk.

cc: Michael Schum, Ph.D.
Staff Toxicologist, HERD

Attachments

REFERENCES

Battelle, Environmental Restoration Department, (2001). Final Revised Risk Assessment for Former UST Site 957/970 Department of Defense Housing Facility Novato, California.

USEPA National Center for Environmental Assessment, (2002a). CASRN 100-41-4 Risk Assessment Issue Paper titled: Derivation of an Inhalation Unit Risk for Ethylbenzene

US EPA Region XI Preliminary Remediation Goals, (2002b). Memorandum from Stanford Smucker, Ph.D., Regional Toxicologist. (http://www.epa.gov/region09/waste/sfund/prg/index.htm).

USEPA Office of Emergency and Remedial Response, (2000). User's Guide For The Johnson And Ettinger (1991) Model For Subsurface Vapor Intrusion Into Buildings (Revised). (http://www.epa.gov/oerrpage/superfund/programs/risk/airmodel/johnson_ettinger.htm)

ATTACHMENT 1

Table 1. Chemical Risks of Individual Exposure Pathways for a Hypothetical Residential Receptor in the Sale Area

Contaminant	Direct contact of soil	Outdoor air from groundwater	Outdoor Air from Soil	Indoor Air
Ethylbenzene	1.30E7	2.32E-7	3.71E-7	3.70E-8
Benzene	1.05E-6	7.23E-6	5.22E-6	1.30E-5
MTBE	5.34E-8	1.32E-7	3.13E-8	4.80E-7
All contaminants (total risk)	1.23E-6	7.59E-6	5.62E-6	1.35E-5

Table 2. Chemical Risks of Individual Exposure Pathways for a Future Industrial Receptor in the Sale Area

Contaminant	Direct contact of soil	Outdoor air from groundwater	Outdoor air from soil	Indoor air
Ethylbenzene	2.66E-8	1.09E-7	1.740E-7	2.20E-8
Benzene	2.19E-7	4.30E-6	3.11E-6	7.90E-6
MTBE	1.11E-8	7.84E-8	1.86E-8	3.00E-7
All contaminants (total risk)	2.57E-7	4.49E-6	3.30E-6	8.22E-6

Theresa McGarry
Attachment 2
Page 1
08/05/03

Table 1. Indoor Air Model Results of Ethylbenzene for a Hypothetical Residential Receptor in the Sale Area

DATA ENTRY SHEET

DTSC/HERD 12/1/01

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
100414			4.25E-02	Ethylbenzene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm^2)
15	91.44	15			3.03E-08

MORE ↓

ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)
1.4	0.48	0.1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	Molecular weight, MW (g/mol)
7.50E-02	7.80E-06	7.88E-03	25	8,501	409.34	617.20	0.0E+00	2.0E+00	106.17

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
76.44	0.380	#N/A	#N/A	#N/A	3.03E-08	3,844	1.91E+02	5.63E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Diffusion path length, L_d (cm)
9.24E+05	4.16E-04	15	10,098	4.36E-03	1.84E-01	1.77E-04	1.30E-02	76.44

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)
15	1.91E+02	0.10	2.90E+01	1.30E-02	3.84E+02	7.95E+37	4.34E-04	8.29E-02

Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
1.1E-06	1.0E+00

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
3.7E-08	7.8E-05

MESSAGE SUMMARY BELOW:

END

Table 2. Indoor Air Model Results of Ethylbenzene for a Future Industrial Worker Receptor in the Sale Area

DATA ENTRY SHEET

DTSC/HERD 12/1/01

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
100414			4.25E-02	Ethylbenzene

MORE ↓	ENTER Depth below grade to bottom of enclosed space floor, L_F (15 or 200 cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vadose zone soil vapor permeability, k_v (cm^2)
	15	91.44	15			3.03E-08

MORE ↓	ENTER Vadose zone soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Vadose zone soil total porosity, n^V (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^V (cm^3/cm^3)
	1.4	0.48	0.1

MORE ↓	ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
	70	25	25	250

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	Molecular weight, MW (g/mol)
7.50E-02	7.80E-06	7.88E-03	25	8,501	409.34	617.20	0.0E+00	2.0E+00	106.17

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
76.44	0.380	#N/A	#N/A	#N/A	3.03E-08	3,844	1.91E+02	5.63E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Diffusion path length, L_d (cm)
9.24E+05	4.16E-04	15	10,098	4.36E-03	1.84E-01	1.77E-04	1.30E-02	76.44

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)
15	1.91E+02	0.10	2.90E+01	1.30E-02	3.84E+02	7.95E+37	4.34E-04	8.29E-02

Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
1.1E-06	1.0E+00

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.2E-08	5.6E-05

MESSAGE SUMMARY BELOW:

END